Azimuthal correlations between D mesons and charged particles in pp collisions at $\sqrt{s}$ =13 TeV with ALICE

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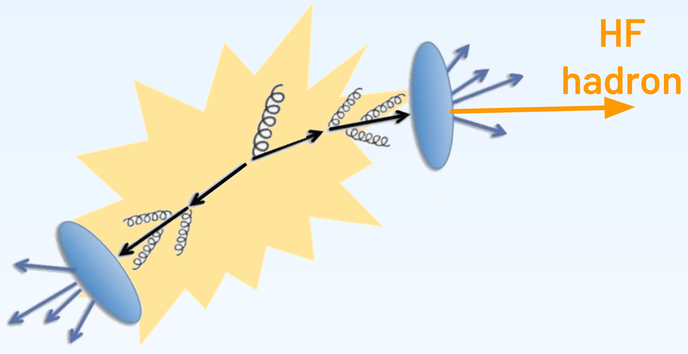
ALICE

Physics motivations

Angular correlations between heavy-flavour and charged particles provide a tool for the investigation of the heavy-flavour quark **production** and *fragmentation* mechanisms and can shed light on the the heavy quarks interactions with the medium created in heavy-ion collisions.

- ✓ in proton-proton (**pp**):
  - characterize charm quark jets and study their properties
  - sensitive to LO and NLO production mechanisms
  - validation of Monte Carlo algorithms
  - baseline for larger-system studies
- ✓ in **p-Pb**, asses **Cold Nuclear Matter** effects (***CNM***)
- ✓ in lead-lead (**Pb-Pb**):
  - study medium-induced modifications of HF *fragmentation*
  - detail and understand the energy loss dependence on path length in the medium



The ALICE detector

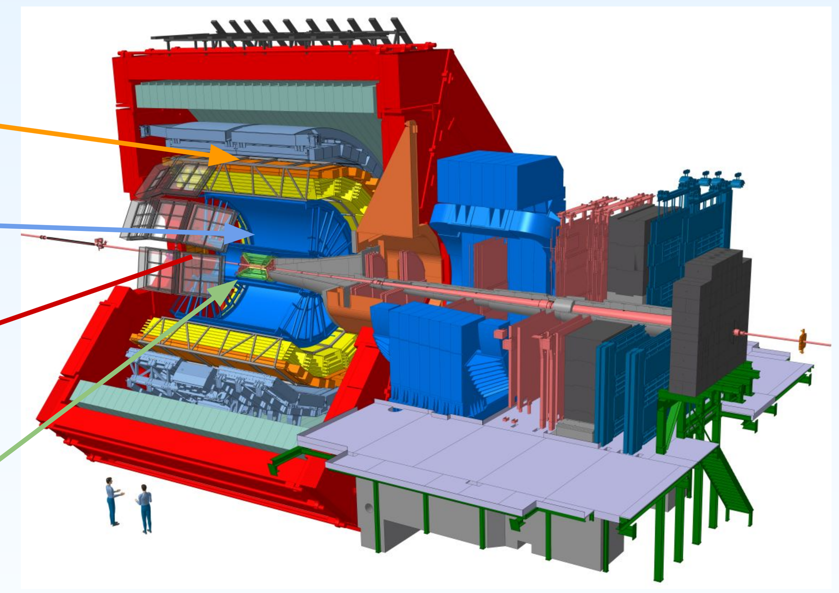
General-purpose experiment at LHC devoted to study the physics of strongly interacting matter. The subsystems used for the analysis are:

Time Of Flight (**TOF**): PID via time of flight

Time Projection Chamber (**TPC**): tracking and PID via dE/dx

V0: trigger and event selection

Inner Tracking System (**ITS**): tracking, vertexing



Observables

The azimuthal correlation distributions generally feature two peaks: a Near-Side peak centered in Δφ = 0, and an Away-Side (AS) peak, around Δφ = π and usually wider.

✓ Near Side (NS): particles collimated with the trigger D meson

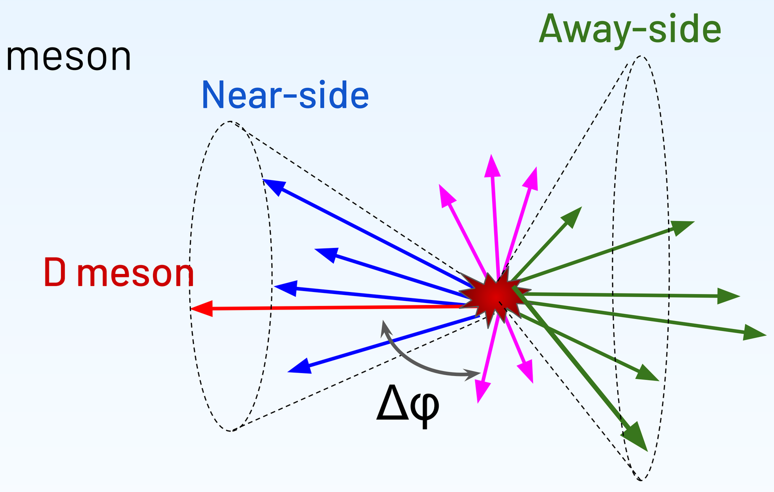
→ *fragmentation* of the *charm* quark originating the reconstructed D meson;

✓ Away Side (AS): particles opposite to the trigger

→ *fragmentation* of the other *charm* quark;

✓ Transverse Region: particles not correlated

→ details the *underlying event*

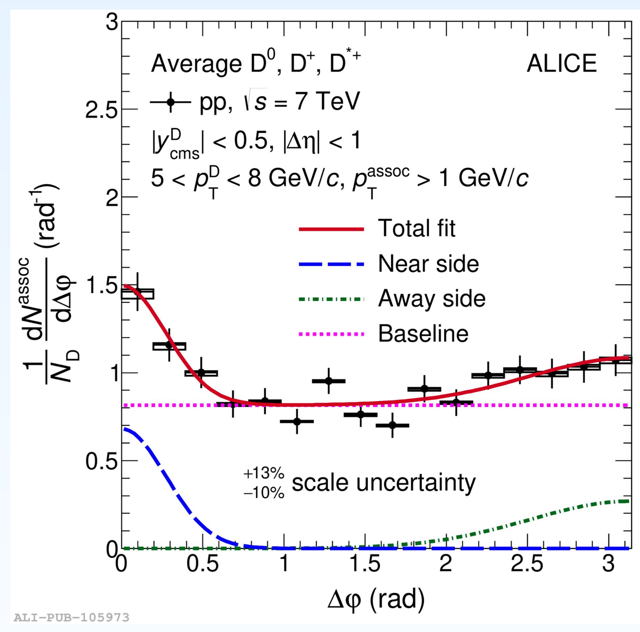


$$f(\Delta\varphi) = a + \frac{Y_{NS} \times \beta}{2\alpha\Gamma(1/\beta)} \times e^{-\left(\frac{\Delta\varphi}{\alpha}\right)^{\beta}} + \frac{Y_{AS}}{\sqrt{2\pi}\sigma_{AS}} \times e^{-\frac{(\Delta\varphi-\pi)^2}{2\sigma_{AS}^2}}$$

From the fit of the Δφ distribution, it's possible to extract:

- **yields**(Y_{NS} , Y_{AS}) - the integral under the relative correlation peak → indicators of particle multiplicity
- **widths**(σ_{NS}, σ_{AS}) → proxy for the jet-cone angular opening.

$$\sigma_{NS} = \alpha\sqrt{\Gamma(3/\beta)/\Gamma(1/\beta)}$$



Results

Results in pp at $\sqrt{s}$ =13 TeV and comparisons with lower energies

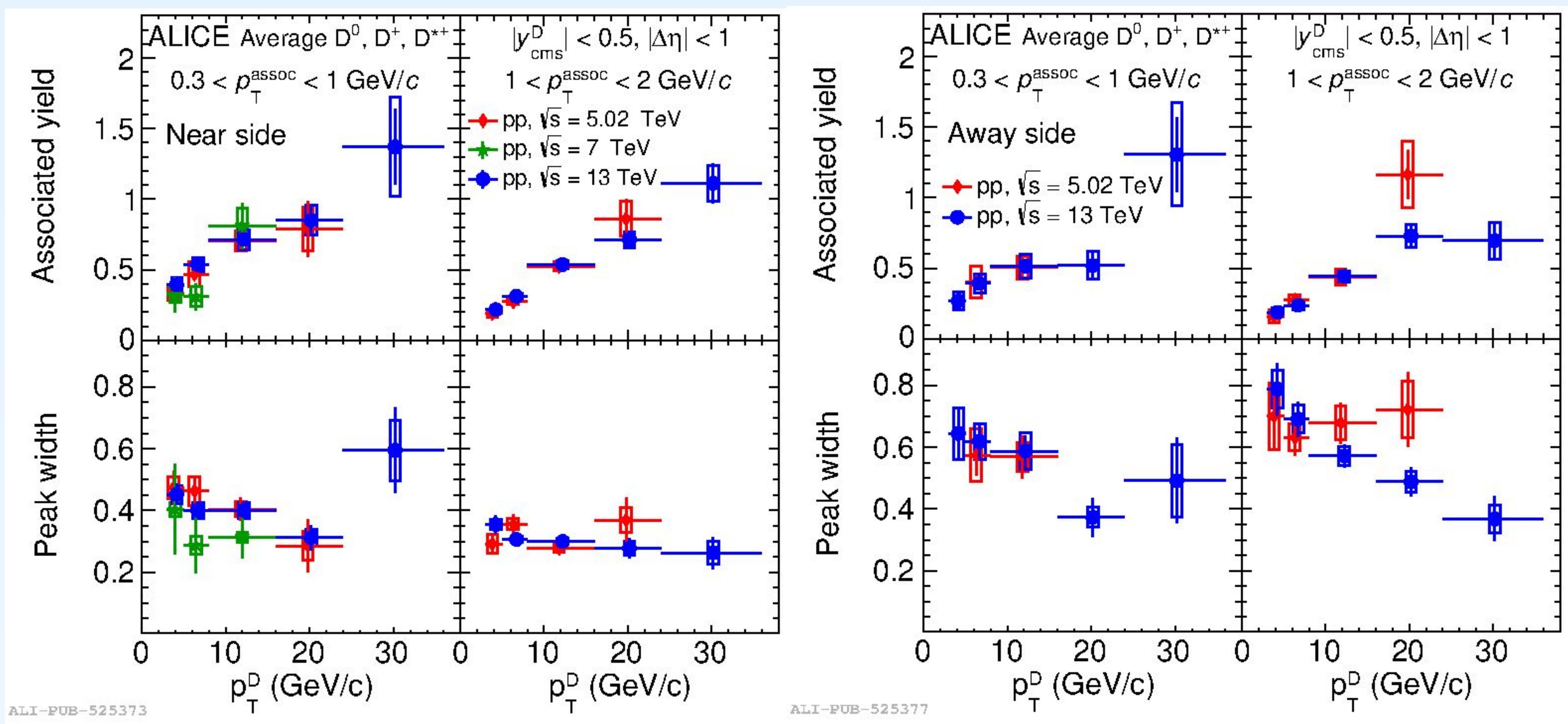
A good agreement between the D-h azimuthal correlation distributions at $\sqrt{s}$ = 13 TeV[2] distributions and previous measurements in pp collisions at $\sqrt{s}$ = 5 and 7 TeV[3,4] was observed, after the subtraction of the baseline "a".

The **yields** and the **widths** were studied in several ranges of D-meson (p_T^D) and charged particle (p_T^{assoc}) transverse momenta:

→ Increasing trend of the NS yields with p_D^T, compatible within the uncertainties with lower energies measurements

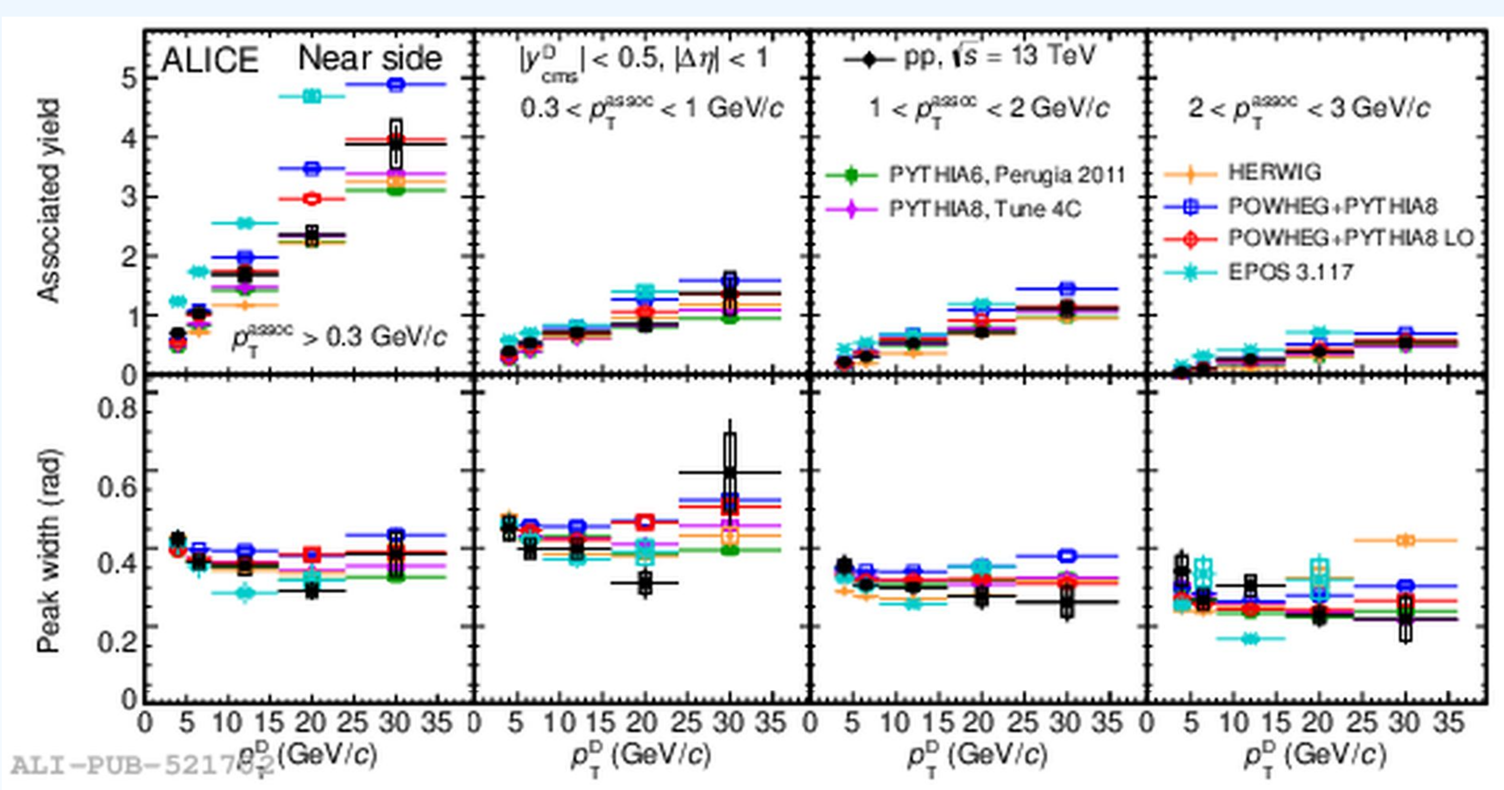
→ Hint of NS peak narrowing in $\sqrt{s}$ = 13 TeV data with increasing p_D^T
→ particles produced more collimated with D meson direction
→ Increased boost of the fragmenting (splitting) parton with p_T^D

→Similar considerations can be drawn for the AS, whose narrowing is more evident with respect to the NS



Comparisons with Monte Carlo expectations

Data results are compared to expectations from Monte Carlo generators:



→ Hierarchy in yield values: EPOS[5] systematically overestimating the data, followed by **POWHEG+PYTHIA8 NLO**, POWHEG+PYTHIA8 LO, and then by PYTHIA6 and PYTHIA8[6,7].

→ **POWHEG+PYTHIA8 NLO** provides a better description than the LO implementation at low p_T^D in describing the width → important contribution of NLO processes.

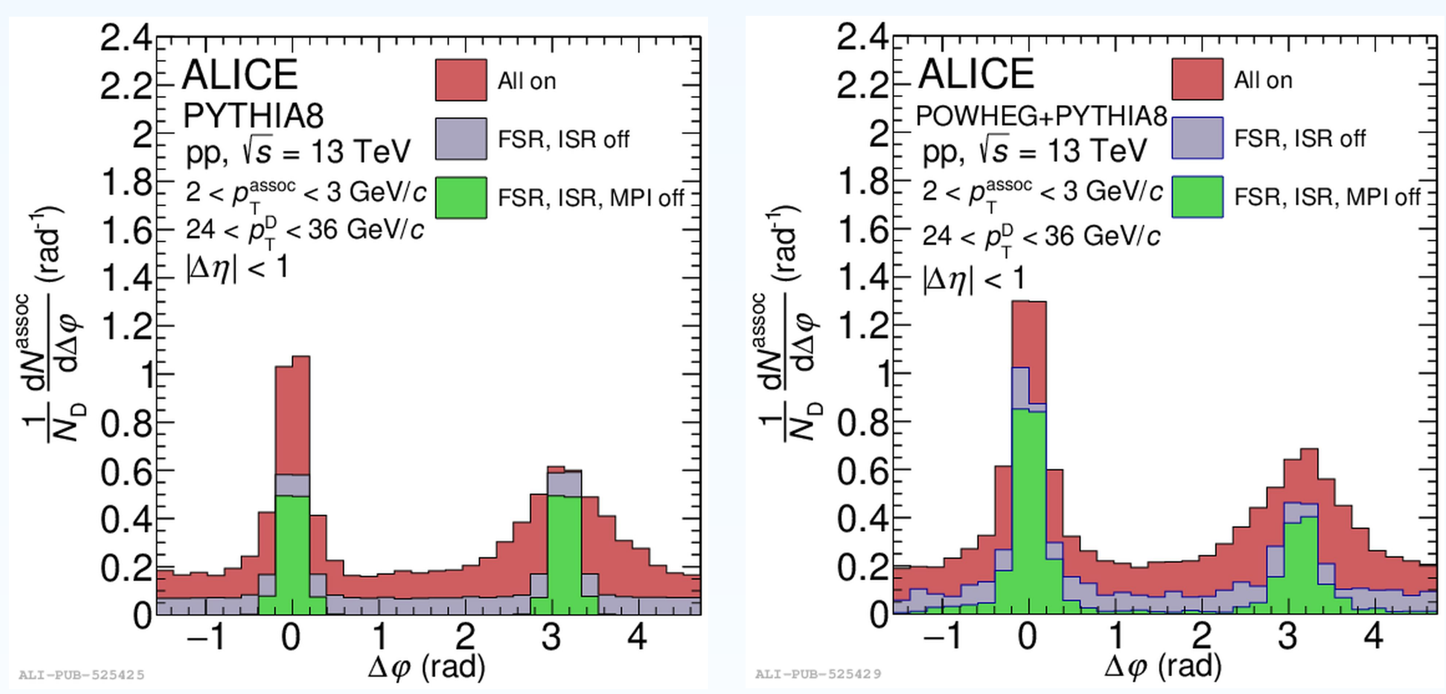
→ The best description is provided by **POWHEG+PYTHIA8** and by PYTHIA8 generator

Parton level studies

A more detailed investigation was performed using **POWHEG+PYTHIA8 NLO** and **PYTHIA8** models to expose how different stages of the event modelisation contribute in building the azimuthal correlation shape.
Initial and **Final State Radiation** (**ISR** and **FSR**) and **Multi Parton Interactions** (**MPI**) were considered and sequentially excluded in the event generation, enhancing the differences in the two model expectations:

→ from the hard scattering, **POWHEG+PYTHIA** foresees wider peaks and a less pronounced AS peak with respect to PYTHIA8 predictions because of NLO production mechanisms contribution (***gluon splitting***).

→ parton showering processes in **PYTHIA8** reconcile most of the differences in the correlation peak shape, with some residual discrepancies in the NS yields.



Conclusions

- ✔ D-hadron correlations in pp provide relevant information on the properties of charm **production** and **fragmentation**
- ✔ Differential description of **charm jet shape** and momentum **composition**
- ✔ Excellent tool for the **validation** of the **Monte Carlo models**
- ✔ Reference for heavy-ion collisions:
  - **p-Pb**[3]: no evidence of **CNM** effects
  - **Pb-Pb**: not feasible in Run2, measurement prospect for Run3

References

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[5] T. Pierog, EPJ Web Conf. 210 (2019)
[6] E. Bothmann et al, SciPost Phys.7 (2019)
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